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Aircraft Battle Damage Assessment and Repair (ABDAR) Final Program Report

Volume 1: Executive Summary

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FOR THE COMMANDER

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13. ABSTRACT *(Maximum 200 words)*
This is the first of three volumes describing the results of a program to develop technology to enhance the Aircraft Battle Damage Assessment and Repair (ABDAR) process. This volume provides an executive summary and describes the overall program goals, the methodology used to develop the ABDAR technology and a demonstration system, and the results of a field test conducted to evaluate the effectiveness of the ABDAR technology and its benefits. The approach adopted was to develop an automated capability to provide aircraft battle damage assessors with technical data and assessment tools via a portable maintenance aid. A demonstration system was developed and used to evaluate the ABDAR concept. The ABDAR Demonstration System developed was an end-to-end system. It started with the aircraft debrief and continued through the ABDAR process to final documentation of the damage assessment on an Air Force Technical Order (AFTO) Form 97. The demonstration system provided the assessor with technical data for the testbed aircraft (F-15A), including applicable aircraft battle damage repair manuals and Technical Order (TO) 1-1H-39, Technical Manual General Aircraft Battle Damage Repair. The system supports two types of Electronic Technical Information (ETI). The first type of data, in the Indexed Portable Document Format (IPDF), presents technical data electronically in a format very similar to the paper TO. The second type of ETI, in the Content Data Model (CDM) format, provides technical data in an interactive mode. Sample technical data was developed in both formats. The field test results demonstrated that the use of the ABDAR system significantly improves the speed, accuracy and completeness of assessments.

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PREFACE

The research documented in this technical report was sponsored by the Air Force Research Laboratory, Deployment and Sustainment Division, Logistics Readiness Branch. This volume is the first of three volumes that summarize work performed to develop an Aircraft Battle Damage Assessment and Repair (ABDAR) technology to enhance the capability of Air Force technicians to assess damage, determine needed repairs and restore the aircraft to operational status. The work was funded under PE63106F, Project 2745. The work was performed under contract F41624-95-C-5003 by NCI Information Systems, Inc., with subcontractor support from Boeing Aircraft Company, RJO Enterprises, Inc., and GRACAR Corporation. Captain Michael Clark and 1st Lieutenant Steve Grace were the program managers for the major portion of the effort. Other Laboratory personnel who made major contributions earlier in the program were Captain Eric Carlson, Captain Floyd Gwartney, 1st Lieutenant J.C. Bradford, and 1st Lieutenant Maurice Azar.

This research could not have been accomplished without the support and assistance of many members of the Combat Logistics Support Squadrons, the Aircraft Battle Damage Repair Program Office, and the Air Force Materiel Command Logistics Directorate who served as members of the ABDAR Users Group, provided technical guidance throughout the program, and provided program advocacy.

The 653rd Combat Logistics Support Squadron, Robins AFB provided extraordinary support for the program. The 653rd provided the test facilities, test aircraft, and many of the technicians who participated in the field test. The squadron also provided the support of several of their instructors who served as subject matter experts and advisors throughout the program. The contributions of MSgt Ken McCain, TSgt Geoffrey Miller, TSgt George Boutwell, TSgt Ken Dockery, and TSgt Rob Meyers as technical advisors were invaluable and greatly appreciated by the ABDAR program staff.

The Executive Summary is the first volume of a three-volume final program report. It contains a summary of the objectives, assumptions, methodology, results, conclusions, and recommendations of the Aircraft Battle Damage Assessment and Repair (ABDAR) program.

SUMMARY

The principal objective of this program was to develop and evaluate technology to significantly enhance the speed, accuracy, and completeness of the assessment of battle damaged aircraft. The approach adopted was to develop an automated capability to provide aircraft battle damage assessors with technical data and assessment tools via a portable maintenance aid (PMA). A demonstration system was developed and used to evaluate the Aircraft Battle Damage Assessment and Repair (ABDAR) concept. The ABDAR Demonstration System developed for the field test was an end-to-end system. It started with the aircraft debrief and continued through the ABDR process to final documentation of the damage assessment on an Air Force Technical Order (AFTO) Form 97. The system design was based upon a prioritized set of requirements identified by the ABDAR Users Group (AUG). The demonstration system provided the assessor with technical data for the testbed aircraft (F-15A), including applicable F-15 aircraft battle damage repair (ABDR) manuals and Technical Order (TO) 1-1H-39, Technical Manual General Aircraft Battle Damage Repair. The system supports two types of Electronic Technical Information (ETI). The first type of data, in the Indexed Portable Document Format (IPDF), presents technical data electronically in a format very similar to the paper TO. The second type of ETI, in the Content Data Model (CDM) format, provides technical data in an interactive mode. Sample technical data was developed in both formats. The benefits and effectiveness of the two formats were evaluated in a field test.

A field test was conducted at Robins AFB to evaluate the effectiveness of the system. The evaluation was accomplished by having technicians assess simulated battle damage on an F-15 aircraft. Two thirds of the technicians assessed the damage using the demonstration system, and one third of the technicians performed the assessment while using the paper technical orders. Half of the technicians using electronic technical data used the CDM version, and half used the IPDF version. Three types of technicians performed the assessment task. They were fully qualified F-15 battle damage assessors, battle damage assessors qualified on another aircraft, and technicians (F-15 crew chiefs) who were not trained in aircraft battle damage assessment. Test results demonstrated significant benefits to using the ABDAR demonstration system for both the IPDF and CDM versions of the technical data.

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AIRCRAFT BATTLE DAMAGE ASSESSMENT AND REPAIR (ABDAR)
FINAL PROGRAM REPORT
VOLUME 1: EXECUTIVE SUMMARY REPORT

INTRODUCTION

The ABDAR final program report consists of three volumes.

a. Volume 1, Executive Summary, contains a summary of the objectives, methodology, results, conclusions, and recommendations of the entire program.

b. Volume 2, Program Methodology, contains an overview of the methodology used to satisfy the objectives of the ABDAR program.

c. Volume 3, Field Test, contains the results, conclusions, and recommendations, resulting from the field test.

The program objective was to develop and demonstrate technology that would provide a significant enhancement in the capability of USAF aircraft battle damage repair (ABDR) assessors and technicians to rapidly assess battle damaged aircraft. These individuals face the critical task of assessing, repairing, and returning battle damaged aircraft to mission readiness during wartime. The ABDAR program built upon the concepts and technology developed in the Laboratory's Integrated Maintenance Information System (IMIS) program (Ward, et al. 1995, Volumes 1, 2, 3, and Thomas, 1995) and an aircraft battle damage assessment concept developed in an earlier study (Wilper, et al. 1983). The basic approach in the IMIS program was to provide technicians with a portable maintenance aid (PMA) capable of presenting all technical and diagnostic information required to perform their jobs. A similar approach was adopted for the ABDAR program. Technology and a demonstration system were developed to provide the ABDAR assessor with information and planning tools needed to perform and document the assessment task.

The ABDAR process supported by the demonstration system started at aircraft debrief and finished with final documentation of the damage on Air Force Technical Order (AFTO) Form 97. The ABDAR demonstration system supported the Aircraft Battle Damage Repair (ABDR) process by providing the assessor with technical data for a range of aircraft systems. The data was derived from applicable ABDR manuals, including TO 1-1H-39, Technical Manual General Aircraft Battle Damage Repair. The system handles two types of electronic technical information (ETI) formats, the Indexed Portable Document Format (IPDF) and the Content Data Model (CDM) format.

In addition to development of the ABDAR demonstration system, the ABDAR program included a field test to evaluate the effectiveness of the system and determine its benefits. The field test also compared the benefits of the two types of electronic

technical data. To accomplish the evaluation, it was necessary to select a testbed aircraft, inflict simulated battle damage to the aircraft, and develop technical data, in the electronic formats, needed to accomplish the assessment task. Fact finding visits to the Combat Logistics Support Squadron (CLSS) units and other information led to the selection of the F-15A as the testbed aircraft. Damages were inflicted on an F-15A aircraft. The damages were inflicted at door R6 and the left wing trailing edge. The damages involved aircraft systems, structure, and wiring. The field test was conducted at Robins Air Force Base (AFB), GA, beginning in September 1998. The test consisted of two distinct phases: Phase I - ABDAR process Paper Technical Data version and Phase II - ABDAR process ETI version. This volume of the report describes the basic procedures used to develop the ABDAR demonstration system and summarizes the field test results.

Purpose

The objective of the ABDAR program was to design, develop, and evaluate an ABDAR Demonstration System that would significantly enhance the speed, accuracy, and completeness of the assessment of battle damaged aircraft.

Scope

The ABDAR program was designed to allow maximum transfer of information from one phase of the program to the next phase. Significant emphasis was placed on involving "real world" users throughout the program to ensure that the system developed meets their needs and to facilitate product transition to the user community. The overall scope of the ABDAR program included:

a. Identifying and defining the requirements for an ABDAR Demonstration System.

b. Developing specifications that define the ABDAR Demonstration System requirements.

c. Designing and developing an ABDAR Demonstration System capable of supporting the essential ABDR requirements.

d. Evaluating the ABDR concept, demonstration system, and requirements using the ABDAR Demonstration System in a field test.

e. Incorporating the results of the tests, demonstrations, and evaluations conducted into the final report.

ABDAR PROGRAM OVERVIEW AND APPROACH

The ABDAR program prime contract was awarded in August 1995. The project was conducted in three phases; requirements analysis, system design and development, and demonstration system implementation and field test. The system was to be capable of displaying two types of ETI and to show improvements in the speed,

accuracy, and completeness of damage assessments, over the current ABDR method. An extensive data collection effort was conducted in year one to establish user requirements. System design, system development, and the field test were accomplished in years two through four. Planning for the field test occurred in years two and three, with the field test being conducted in year four, from September 1998 to October 1999. Most transition planning occurred between August 1998 and December 1999. The overall schedule for the program is presented in Figure 1.

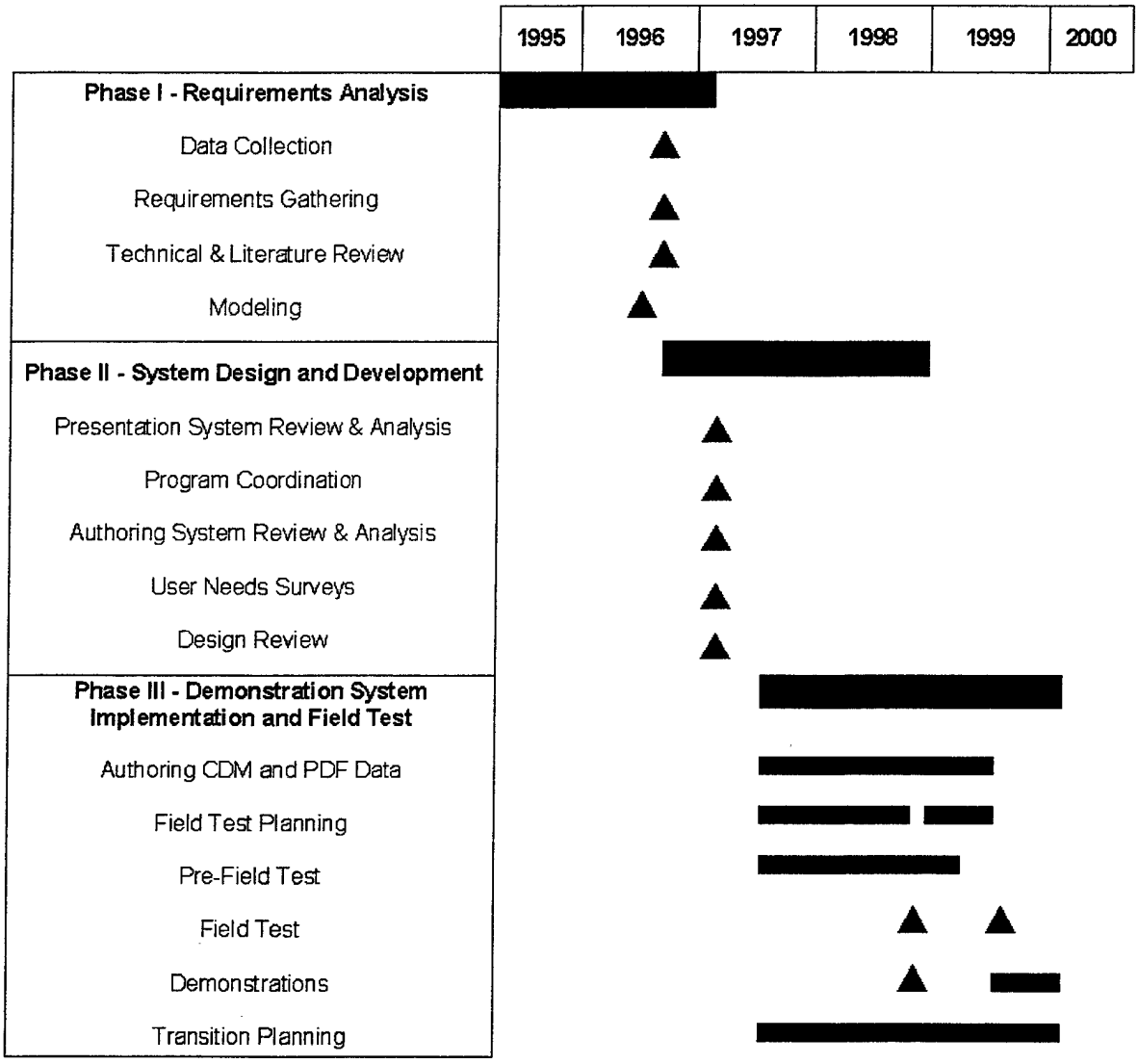

Figure 1. High Level Schedule

NCI used a prototype method of evolving the system (referred to as the Interim Software Demonstration [ISD] process). Each ISD was reviewed at the ABDAR Users Group (AUG) meetings, where user feedback was obtained and plans made for the next iteration of software development. Figure 2 provides a pictorial representation of the ISD development process used throughout the program.

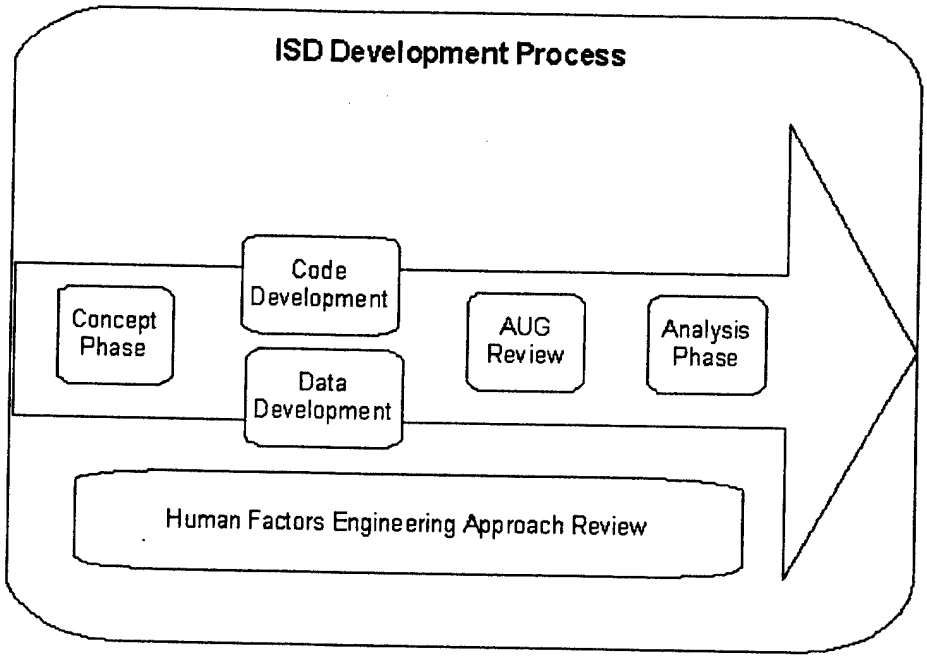

Figure 2 – ISD Development Process

ABDAR REQUIREMENTS ANALYSIS

A systematic process was used to identify, record, and track system requirements during the initial analysis phase. Requirements definition focused on the end-user.

Data Collection

Methods used to gather and identify requirements included interviews with ABDR personnel, a literature review, and a "user needs survey".

a. Interviews with ABDR personnel took place over the course of several months. The ABDAR Team visited 13 USAF bases. All interviews were recorded on audiotape, providing convenient reference in areas where the interviewer's notes were not clear. After each data collection trip, the interviewers compiled their notes and submitted them to a data modeler for entry into the user needs database.

b. A literature review was performed to avoid duplication of effort with other existing ABDR efforts. This review was also designed to identify other potential sources for ABDAR Demonstration System requirements. The review had two focal points; reviewing documentation associated with IMIS program and reviewing documentation associated with aircraft battle damage assessment and/or repair.

c. A User Needs Survey was sent to 11 active and reserve Combat Logistics Support Squadrons (CLSS) within the USAF. A total of 133 surveys were completed by experienced ABDR technicians. Survey items were listed in the

form of need statements. The maintenance personnel assigned a rating to each item using a scale based on the Modified Cooper-Harper scale, traditionally used to measure subjective workload. The rating was based on their level of need for the item to perform their assigned tasks. A list of 159 items related to the capabilities needed to accomplish ABDR tasks were extracted from the data base and used in the definition of the ABDR "As-Is" process.

Integrated Computer Aided Manufacturing (ICAM) Definition Methodology (IDEF)

The IMIS Architecture (IMISA) served as a model and starting point for development of the ABDAR architecture. Combining the IMISA information with data collected in the field working with ABDR subject matter experts (SMEs) resulted in a realistic portrayal of the ABDR process and its interfaces to the organizational-level maintenance environment modeled by the IMIS program.

Knowledge-Based Systems, Inc.'s modeling tools were used to model the functions, processes, and information requirements for the ABDR domain. Three IDEF models were developed. The IDEF0 model depicted a hierarchical representation of the activities and information flows of the ABDR world. The IDEF3 model was a Process Flow Network (PFN). The ABDAR IDEF1x models were based on the IMIS "As-Is" IDEF1x model and the ABDAR IDEF0 model. Each entity and relationship in the IMIS "As-Is" IDEF1x model was examined for inclusion in the ABDAR IDEF1x model. IDEF1x was useful in defining database structures and conceptual models during system development.

System/Subsystem Specification (SSS)

The ABDAR SSS defined the requirements for an ABDAR System. The ABDAR SSS described the system as encompassing activities, processes, and information associated with technicians, assessors, team chiefs, and maintenance supervisors. The SSS defined the capabilities required for an operational system.

Identification of Demonstration Requirements

Using the ranking structure provided by the ABDAR User Needs Survey, a subset of requirements was selected from the ABDAR SSS for use in developing the ABDAR Demonstration System. The subset of requirements was selected to be sufficient to develop a demonstration system with the capabilities and features required to effectively demonstrate and evaluate the ABDAR concept. In October 1996, the recommended demonstration system requirements were presented to and approved by the AUG and the Government Program Manager (PM).

Another key aspect of demonstration requirements was the field test environment itself. This included location, type of aircraft, types of damages, aircraft damage sites, and the actual damages. Fact finding visits and other information obtained resulted in the selection of Robins AFB, GA as the test site and the F-15A as the testbed aircraft.

Damages involving system, structure, and wiring were inflicted on the F15 at locations door 6R and left wing trailing edge. These sites were used as damage sites for use in the evaluation. These decisions determined the actual data requirements, which were a significant part of the system development effort.

ABDAR DEMONSTRATION SYSTEM DEVELOPMENT

The ABDAR Demonstration System was developed using a methodology called evolutionary prototyping. Evolutionary prototyping is a life-cycle model, which defines the system concept as the product is developed. Development of the most visible aspects of the system was first. These visible aspects were demonstrated to the user through an Interim Software Demonstration (ISD), and then the next ISD was developed based upon user feedback, system performance, and the additional requirements needed for a fully functioning system. The evolutionary prototyping method produced steady, visible signs of progress.

The development team produced six ABDAR Demonstration System ISDs. Four of the ISDs were used in developing the demonstration system. The fifth ISD explored advanced concepts outside the requirements of the field test. The sixth ISD documented the field test version of the software. Several processes were utilized in the development of each ISD. These processes consisted of a concept phase, code development, data development, AUG review, human factors engineering approach review, and an analysis phase.

ISD #1- HyperText Markup Language (HTML) Prototype

The objective of ISD #1 was to present visual objects to the AUG allowing their input to guide the definition of the functionality and appearance of the ABDAR Demonstration System. The assumption was made that by incorporating the users' perspective early in the design process, the ABDAR team would be better able to ensure that the final ABDAR Demonstration System would serve the users' needs.

ISD #2 – Damage Collection

The rationale for ISD #2 was to begin system development on the portions of the ABDAR Demonstration System that were considered the highest risks and that contained the highest potential payoff to the program. The most significant components that concentrated on the core assessment functions were Damage Collection and Repair Planning. Damage Collection was the primary focus of ISD #2.

ISD #3 – Repair Planning

The development team concentrated on developing additional essential components in ISD #3 for the ABDAR Demonstration System. Therefore, Repair Planning was the primary focus for ISD #3. A multi-tier architecture was developed for use in ISD #3 and

successive ISD's. A database architecture was deployed to support the remaining iterative prototypes of the software. The database was implemented to evolve along with the prototype applications.

ISD #4 – Field Test Version

The development team concentrated on producing a robust version of the system that could support a field test. The biggest risks to the development of the ABDAR Demonstration System were an immature development language and environment, and the ability of test subjects to use the system with minimal training. To mitigate risks, the ABDAR Demonstration System was modified from a series of applets to a single application.

ISD #5 –ABDR Technology Concepts

Unlike previous ISDs, ISD #5 was not an iterative step in the development of the ABDAR Demonstration System; rather, it was a collection of thought-provoking ideas to enhance the ABDR assessment process. The ISD #5 concept and analysis paper documented the ideas and results produced during that effort. The ISD #5 concept paper is provided as an appendix to Volume 2 of this report.

ISD #6 – Documenting the Field Test Version

The objective of ISD #6 was to document the field test version (ISD #4) of the software for delivery to AFRL/HESR at program end as ISD #6. No major software, hardware, or database changes were required.

FIELD TEST OVERVIEW

The field test provided a structured approach for evaluation of the ABDAR concept and Demonstration System. The field test was accomplished at Robins AFB between September 1998 and October 1999. The specific goals of the field test were:

a. To determine if the ABDAR Demonstration System improves the speed, accuracy, and completeness of the ABDAR process.

b. To collect data that clearly identifies benefits, advantages and disadvantages of the ABDAR Demonstration System for supporting the damage assessment process, when compared to the current paper based method.

c. To evaluate the relative performance benefits of technical data developed in the IPDF and CDM formats.

d. To identify necessary changes in the ABDAR SSS to provide the basis for development of the most effective battle damage assessment system for operational implementation.

Field Test Results

The field test compared three media types (CDM, IPDF, and Paper). Three categories of technicians participated in the evaluation. They were ABDR assessors qualified on the F-15, ABDAR assessors qualified on other aircraft (e.g., F-16, C-130), and F-15 Mechanics. The data collected was analyzed as two separate experiments, with data from the ABDR trained subjects evaluated in one experiment and data from the F-15 mechanics evaluated in the second experiment.

The first experiment was a 2 x 3 factorial design with technician type (F-15 Assessor and Other Assessor) and media type (Paper, IPDF, and CDM) as the independent variables. Dependent variables were time, accuracy, and completeness. Separate Analysis of Variance (ANOVA) tests were performed on each dependent variable. Subjects for the first study consisted of 30 USAF maintenance ABDAR qualified technicians. All were qualified at the skill level seven (7-level) in their Air Force Specialties, Aircraft General Technician and Sheet Metal Specialist. Fifteen were ABDAR qualified F-15 assessors and 15 were ABDAR qualified assessors on other aircraft. The mean scores on each measure are summarized in Table 1.

Table 1. Summary of Scores for F-15 Assessors and Other Aircraft Assessors[1]

Measure	CDM	IPDF	Paper
Time (Minutes)[2]	337.6	629.6	447.9
Completeness [3]	95.4%	90.3%	56.8%
Accuracy [4]	90.9%	83.3%	39.8%

[1] Scores combined for F-15 and other aircraft assessors
[2] CDM and Paper significantly faster than IPDF ($p < .001$)
[3] CDM and IPDF significantly higher than paper ($p < .001$)
[4] CDM and IPDF significantly higher than paper ($p < .001$)

No statistically significant differences were found between the performances of the F-15 and other aircraft qualified assessors on any of the measures. Subjects using the ABDAR Demonstration System with CDM data performed significantly faster than subjects using the ABDAR Demonstration System with IPDF data, improving the overall time by 86%. Assessments produced by subjects using CDM and IPDF data were significantly more accurate and complete than those produced by subjects using Paper, regardless of Technician Type. Subjects using CDM were 39% more complete and 51% more accurate than subjects using Paper. Subjects using IPDF were 34% more complete and 44% more accurate than subjects using Paper. Overall, the ABDAR

Demonstration System tools, in conjunction with electronic technical data, provided a significant advantage over the current, paper-based method of performing ABDR.

The second experiment was a 1 x 3 design with F-15 Mechanics performing the same tasks as above with the three media types (Paper, IPDF, and CDM). Dependent variables were time, accuracy, and completeness. Separate One-Way Analysis of Variance (ANOVA) tests were performed on each dependent variable. Subjects consisted of 18 USAF maintenance AFS 5 and 7-level qualified individuals. The mean scores on each measure are summarized in Table 2.

Table 2. Summary of Scores for F-15 Mechanics

Measure	CDM	IPDF	Paper
Time (Minutes)[1]	288	580.3	389.8
Completeness [2]	95.0%	92.8%	55.2%
Accuracy [3]	92.6%	86.5%	33.7%

[1] CDM and Paper significantly faster than IPDF ($p < .001$)
[2] CDM and IPDF significantly higher than paper ($p < .001$)
[3] CDM and IPDF significantly higher than paper ($p < .001$)

The performance times, and completeness and accuracy scores for the F-15 Mechanics were very similar to those for the experienced assessors. Times with CDM and paper were significantly faster than with IPDF, with no significant differences between performance times for CDM and paper. Completion and accuracy scores for CDM and IPDF were significantly higher that scores for paper. There were no significant differences in the completeness and accuracy scores for CDM and IPDF. An informal comparison with the data for the F-15 and other aircraft suggests that there was little practical difference in their performance and the performance of the F-15 mechanics. The implication is that in the event that a battle damage assessment is required and a qualified F-15 or other aircraft assessor is not available, an F-15 mechanic can effectively perform the assessment using the ABDAR system. This could be an important advantage in a combat situation in which a damaged aircraft is forced to land at a base with no qualified assessors available.

Analysis of the field test results raised the question of whether the advantages observed for the IPDF data were due to the tools/aids provided by the ABDAR system or simply due to the fact that they were presented electronically. Specifically, were the beneficial results found for the IPDF data due to the enhancements (e.g., additional links) made to the data and the aids (e.g., wizards) provided by the ABDAR system, or were they due to presentation of the information electronically? To provide some data relevant to this issue, an additional data collection period was established to provide a tentative answer. A data collection team returned to Robins AFB to collect data from a new sample of F-15 Assessors. Six F-15 Assessors performed the assessment tasks under the same test and evaluation conditions and rules. For this test, subjects performed a conventional assessment with the use of Joint Computer-aided Acquisition

and Logistics Support (JCALS) standard IPDF TOs instead of paper TOs. The JCALS IPDF data was presented electronically with no additional enhancements or aids. This setup allowed collection of data that would be comparable to the ABDAR enhanced IPDF data and the paper data collected during the field test.

The results of this supplemental data collection effort are summarized in Table 3. The time, completeness, and accuracy data were consistent with data collected in the main part of the study. No significant differences in mean times were found for any of the three media. The mean times were ABDAR IPDF - 594 minutes, JCALS IPDF - 486 minutes, and Paper – 526. For the completeness measure, subjects using IPDF scored significantly higher than both subjects using JCALS IPDF and subjects using paper. Subjects using JCALS IPDF scored significantly higher than subjects using Paper. ABDAR IPDF subjects performed significantly better on the accuracy measure than subjects using either JCALS IPDF or Paper. There were no significant differences for the JCALS IPDF and Paper conditions.

Table 3. Comparison of Scores for ABDAR IPDF, JCALS IPDF, and Paper Conditions (F-15 Qualified Assessors)

Measure	ABDAR IPDF	JCALS IPDF	Paper
Time (Minutes)[1]	594	488	526
Completeness [2]	93.8%	74.4%	60.0%
Accuracy [3]	88%	58%	44%

[1] No significant differences in times.
[2] ABDAR IPDF and JCALS IPDF Completeness scores significantly Higher than scores for paper.
[3] ABDAR IPDF Accuracy scores significantly higher than JCALS and Paper Accuracy Scores, no significant difference between JCALS and Paper scores.

As would be expected, the JCALS IPDF data demonstrates an improvement in performance times over paper resulting from easier access to data and elimination of the need to physically search for and acquire the data. Improvements are also observed for the Completeness variable. The reasons for this improvement are not obvious, but may be due to a greater reliance on the use of technical data, since it was more readily available.

After completing the assessment tasks, using the ABDAR Demonstration system with either CDM or IPDF data, the technicians completed a short questionnaire designed to obtain their reactions to the system and to solicit any suggestions for improving the system. The responses were generally quite positive. Technicians indicated that they liked using the system and believed that it has many potential benefits for operational use. Several expressed a desire to see it implemented soon. Some typical comments are given below.

Question 1. *What aspects of the ABDAR System were most helpful to you in*

performing your job? Typical responses:

"I like how it takes care of filling out the AFTO 97's. Really like the way it takes you to the specific TO area you need to be in, links are very useful."

"The speed in which it performs the task. The way the screen won't switch over unless you process the work correctly."

"K-factors automatically figured for you. No research required with this system. Extremely quick ordering."

"TO's being in the computer, reduces a lot of time looking through books."

Question 2. *What aspects of the ABDAR System did you dislike?* Typical responses:

"Not having detailed parts (information), i.e., fittings had no sizes that were recognizable at a glance."

"Really none, just takes time to get used to the system."

"System slowed to a crawl or even locked up after a few hours of use. I realize that the system is still under design."

"When a qty of 60 for fasteners is needed, then when you allocate you should not need to allocate 60 times for 60 fasteners. A block needs to be added for any deviations and work stoppage."

Question 3. *Are there any changes you would like to see made to the ABDAR System?* Typical responses:

"Sensor touch screens in which you can use a pointer."

"Maybe, install a track ball type mouse."

"Better user friendly controls with voice and video links (if possible)."

Question 4. *Are there any other concerns or comments that you would like to be known?* Typical responses:

"Make one system and improve on that system. TO's should be all standardized. Not fighters, bomber, airlift, i.e. If 27 is for flight controls then it should be for each weapon system."

"I personally need more training to give a better viewpoint on what we really need. Overall it is a vast improvement over having to physically search for info and manually document forms."

"I think it is an excellent program. I think it should be helpful to the assessors who understand the setup and material."

"Make it so! In other words make it happen as soon as possible."

DISCUSSION

The ABDAR Demonstration System was tested in a simulated ABDR environment and demonstrated improvements in speed, accuracy, and completeness over the current ABDR process. Unequivocally, assessors using either CDM or IPDF media types far outperform assessors using Paper. The only advantage assessors using Paper have is a slight improvement in time over assessors using IPDF. However, due to the lack of completeness and accuracy of the assessments by subjects using Paper, the time advantage becomes irrelevant. In other words, because the assessments were not as complete and accurate, it made little difference how quickly they were performed. It is likely that any time advantages gained through paper assessments are lost when the repair process is initiated and the repair technicians must compensate for incomplete information provided by the assessment.

Rapid assessment of a battle damaged aircraft is important, however, it is more important that the assessments be complete and accurate. Comparison of the field test data for the different types of media leads to some interesting observations. Figure 3 presents a plot of the Time data vs Accuracy Data for the four media types. The figure illustrates the relationship between three factors, time, completeness, and cost (where CDM has the highest cost, followed by ABDAR IPDF, JCALS IPDF, and Paper). The best performances in terms of accuracy are provided by the most expensive types of data, CDM and ABDAR IPDF. The less expensive paper technical data and JCALS IPDF data were much less effective for supporting the ABDR assessment task.

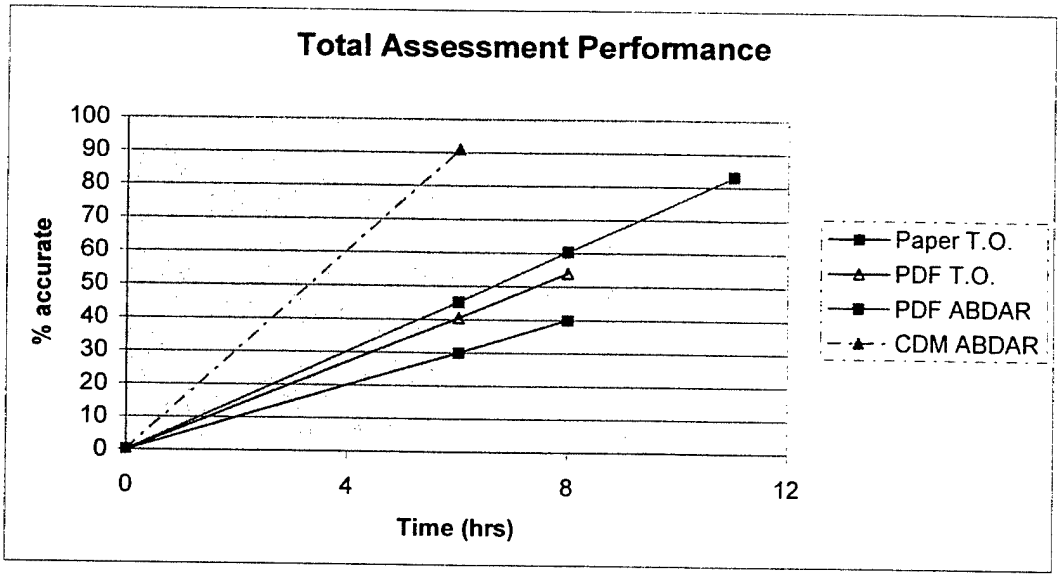

Figure 3. Plot of Accuracy Scores for Four Media Types for F-15 Qualified Assessors

The CDM based data gives the best overall performance, but is generally more expensive. For new weapon systems, which will already have their technical data in the CDM format, the cost of adding ABDAR capabilities will not be great. However, to create CDM data for weapon systems (such as the F-15) would be cost prohibitive, since it requires completely reformatting and restructuring the technical data. For these weapon systems, the development of ABDAR IPDF would be the most cost effective solution. The addition of performance aids and enhancement of the existing JCALS IPDF data would be relatively inexpensive and would provide major improvements in performance.

The performance advantages experienced by assessors using the ABDAR Demonstration System with the CDM and IPDF media types demonstrate the advantages that would be realized if software of this nature were implemented. Assessors using the ABDAR Demonstration System with CDM data outperformed assessors using Paper on every performance measure by statistically significant margins. There is no doubt that using CDM data with the ABDAR Demonstration System is a radical improvement in ABDR methodology compared to using Paper. Assessors using the IPDF data with the ABDAR Demonstration System performed significantly better than those using Paper on performance measures of accuracy and completeness, faltering only on time.

Examination of Figure 2 clearly suggests that the use of CDM data is preferable. The development of CDM data for new aircraft systems is not significantly more expensive than the development of the current paper or JCALS IPDF data. This type of data is being developed for all new weapon systems. The cost of adding the special data elements required by the ABDAR demonstration system to this data should not be significantly more, a relatively small investment for a large potential gain. The development of CDM data for existing systems essentially requires reauthoring the data, which can be quite expensive. The use of IPDF data for these systems is a viable alternative that gains most of the benefits at a relatively small cost. The enhancement of the JCALS IPDF data to incorporate the ABDAR requirements is relatively inexpensive, considering the significant benefits in completeness and accuracy of the assessments produced.

The main disadvantage observed in the field test for the ABDAR IPDF is additional time required to complete the assessments (compared to the CDM and paper based assessments). It is likely that this problem can be reduced somewhat by some enhancements in the user interface. Also, it was observed that in all cases subjects performed faster on the second problem that they performed with the IPDF Demonstration System. This suggests that some of the performance advantages can be overcome with additional training and practice.

CONCLUSIONS

The results of the ABDAR program development and field test support the following conclusions:

1. The use of an electronic technical information system with the capabilities of the ABDAR Demonstration System significantly enhances the ability of technicians to perform the aircraft battle damage assessment task.

2. The use of CDM data with the ABDAR Demonstration System significantly improves the performance of the assessment task by all categories of assessors on all measures.

3. The use of IPDF data with the ABDAR Demonstration System significantly enhances the completeness and accuracy of assessments.

RECOMMENDATIONS

The field test findings support the following recommendations:

a. An electronic technical information system with the capabilities demonstrated in the ABDAR program should be implemented for use by USAF ABDR personnel.

b. For future aircraft, Air Force Materiels Command (AFMC) should ensure that the concepts demonstrated in the ABDAR Demonstration System are incorporated in the presentation systems currently under development. All future weapon systems should utilize CDM data from the beginning of the program and accommodate the ABDAR System needs.

c. Efforts should be made to improve the speed with which assessors use IPDF media with the ABDAR Demonstration System. Improving the IPDF data type, by linking, and improving the IPDF user-interface should reduce the time expended performing ABDR with IPDF. Also, improving the training should improve performance times.

d. The ABDAR program demonstrated that JCALS data can be effectively used to support the assessment task. Therefore, AFMC should continue its efforts to leverage the Joint Computer-Aided Logistics Support (JCALS) initiative to convert paper TO data into electronic format. As the ETI data becomes available from JCALS in an electronic format, AFMC should ensure that the data is made available to all the ABDR Combat Logistics Support Squadrons (CLSSs).

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ACRONYMS

ABDAR	Aircraft Battle Damage Assessment and Repair
ABDR	Aircraft Battle Damage Repair
ACC	Air Combat Command
AF	Air Force
AFB	Air Force Base
AFMC	Air Force Materiel Command
AFMC/LGX	Air Force Materiel Command/Logistics Plans and Programs
AFRL	Air Force Research Laboratory
AFRL/HESR	Air Force Research Laboratory/Deployment and Sustainment Division, Logistics Readiness Branch
AFSOC	Air Force Special Operations Command
AFTO	Air Force Technical Order
ALC	Air Logistics Center
AUG	ABDAR Users Group
CDM	Content Data Model
CFRS	Computerized Fault Reporting System
CLSS	Combat Logistics Support Squadron
DoD	Department of Defense
ETI	Electronic Technical Information
HQ	Headquarters
HTML	HyperText Markup Language
IDEF	Integrated Computer Aided Manufacturing (ICAM) Definition Methodology
IETM	Interactive Electronic Technical Manual
IMDS	Integrated Maintenance Data System
IMIS	Integrated Maintenance Information System
IMISA	IMIS Architecture
IPDF	Indexed Portable Document Format
ISD	Interim Software Demonstration
JCALS	Joint Computer-Aided Logistics Support
JSF	Joint Strike Fighter
MIL STD	Military Standard
OO	Object Oriented
PDF	Portable Document Format
PDSM	Product Data System Modernization
PFN	Process Flow Network
PM	Program Manager
PMO	Program Management Office
PMR	Program Management Review
R&D	Research and Development
SME	Subject Matter Experts
SOO	Statement of Objectives
SOW	Statement of Work
SPO	System Program Office
SSS	System/Subsystem Specification
TO	Technical Order
TTP	Technology Transition Plan
UML	Unified Modeling Language
USAF	United States Air Force
WI	Wiring Illuminator
WPAFB	Wright-Patterson AFB